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Comparing different planning techniques for brain tumour radiotherapy

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Purpose or Objective: The use of volumetric modulated arc (VMAT) is well established for many clinical sites. However, brain tumours are often treated using a 3D cranial radiotherapy (3DCRT) technique with one or two phases. The use of VMAT for cranial radiotherapy is a positive alternative that has been explored by many centres, particularly for brain metastases. Although VMAT provides a more conformal dose across the target volume than conventional planning techniques the main disadvantage is the low dose bath to normal tissue. The potential for additional neurotoxicity must be considered when deciding the best method of treatment. A planning study was conducted to investigate the difference between 3DCRT, co-planar partial arc VMAT and co-planar full arc VMAT.

Material and Methods: Ten patients, who had been clinically treated with VMAT, were selected for this study. Planning target volume (PTV) and organs at risk (OARs), including chiasm, brainstem and normal brain (brain-PTV) were all outlined on these plans. Planning risk volumes (PRVs) were created for each OAR structure. Each patient had three plans produced delivering 6000cGy to the isocentre: two phase 3DCRT with MLC altered to keep each OAR below their tolerance dose, partial arc VMAT and a full arc VMAT plan. For VMAT planning, arcs were applied to the plan and objectives were set for each OAR and PTV in the VMAT optimiser. Full arcs were applied first and then gantry angles amended for an appropriate partial arc (range 169°-239°). Where OARs overlapped the PTV an overlap structure was drawn to limit the dose to the OAR and maximise the coverage to the PTV.

Results: The dose received by 95% of the PTV and the 10cc dose to normal brain are shown in Table 1. Table 1 shows the dose received by 95% of the PTV is greater for VMAT plans than 3DCRT plans. On average, the dose received by 95% of the PTV, for a 3CRT plan, was 5450cGy. In a partial arc VMAT plan, 95% of the PTV received 5659cGy and a full arc VMAT, 5643cGy. The dose colour wash showed a more conformal dose when using VMAT over conventional planning. Table 1 shows that the average maximum dose to 10cc of the normal brain was 5263cGy using 3DCRT, but 4082cGy for partial arc VMAT and 4148cGy for full arc VMAT. Partial arc VMAT, normal brain doses were lower in 7/10 patients.

	Conventional Plan		Partial Arc VMAT Plan		Full Arc VMAT Plan	
Patient	PTV (cGy)	Brain (cGy)	PTV (cGy)	Brain (cGy)	PTV (cGy)	Brain (cGy)
1	5301	6032	5703	4728	5608	4133
2	5409	5592	5741	3896	5649	4172
3	5875	4459	5825	3576	5817	3700
4	5719	4578	5816	4143	5802	4120
5	5779	4371	5798	3617	5843	3813
6	5149	5550	5338	4082	5334	4449
7	5148	5084	5337	4226	5324	3862
8	5362	5598	5738	4123	5733	4436
9	5516	5577	5693	4175	5731	4275
10	5237	5791	5598	4256	5591	4515

Table 1 95% of PTV and 10cc normal brain doses for 10 patients planned three ways

Conclusion: A Planning comparison of 10 patients, each planned using 3DCRT, partial arc VMAT and full arc VMAT was carried out. VMAT plans showed a more favourable PTV coverage compared to 3DCRT. Normal brain dose was lower than 3DCRT. Partial arc VMAT normal brain dose was lower for 7/10 patients than full arcs.

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Comparison of VMAT for single fraction lung cancer radiotherapy with and without flattening filter

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Purpose or Objective: to compare flattening filter free (FFF) and flattening filtered (FF) intensity-modulated arc therapy (VMAT) plans for stereotactic body radiotherapy (SBRT) in patients with lung lesions, delivered in a single fraction of high dose radiation.

Material and Methods: 25 patients were treated with FFF SBRT for lung tumors with a Varian TrueBeam STx LINAC using VMAT. The lesions were treated with single dose of 24 Gy. Two plans, with and without FF, for each patient, were created using Varian Eclipse treatment planning system. Plans were compared and differences were analyzed in terms of dose volume histograms (DVH), number of monitor units (MUs) and beam on time.

Results: No statistically significant differences were found between FFF and FF plans in coverage of the PTV and doses to the main organ at risk (OAR). The PTV conformity index was the same with FFF and with FF VMAT (1.03 ± 0.10). In FFF plans, the maximum doses to spinal cord, heart, esophagus and trachea were 2.9 ±1.9, 0.8 ± 1.2, 3.3 ± 4.4 and 1.5 ± 1.7 Gy respectively. Average lungs V5, V20 and mean doses were 14.6 ± 7.5%, 6.1 ± 3.7% and 1.1 ± 0.6 Gy. In FF plans maximum doses were 3.2 ±2.6, 0.8 ± 1.3, 3.1 ± 4.4 and 1.8 ± 2.0 Gy to spinal cord, heart, esophagus and trachea, and average lungs V5, V20 and mean dose were 15.5 ± 7.9%, 6.3 ± 3.9% and 0.4 ± 0.6 Gy. The average number of MU was slightly higher with FFF beams than with FF (7159 ± 609 vs 7097 ± 699), but the difference was not significant. Beam delivery times were 15.4 with FF beams to 6.7 minutes without filter. Average reduction of treatment time after filter removal was 2.31 ± 0.01 (t-student test $p<0.01$).

Conclusion: The use of FFF VMAT for single fraction SBRT of lung cancer patients yielded dose distributions dosimetrically equivalent to FF beams, with a significantly reduction of treatment delivery time.

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A tool for collision prediction in linac-based intracranial radiosurgery planning

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Purpose or Objective: Gantry collision is a concern in linac-based stereotactic radiosurgery (SRS). Without collision screening, the planner may compromise optimal planning by avoiding advantageous beam angles deemed risky, unnecessary replanning delays can occur, and incomplete treatments may be delivered. To address these concerns, we developed a software for collision prediction based on simple machine measurements.

Material and Methods: Couch points vulnerable to collision including the lateral couch edge were identified. Trigonometry-based formulas to calculate distance from each point to the gantry rotation axis, given the isocenter coordinates relative to the couch position, and the couch rotation angle, were generated. For each point, collision occurs when this distance is superior to the gantry-to-isocenter distance, taking into account the complexity of the gantry collimator facet and the presence of a circular SRS collimator. Once a collision is identified for a specific point, the arc of collision was calculated using a separate formula.The patient was modeled as a parallelepiped with